Analysis of the QBSS Load Element Parameters of 802.11e for a priori Estimation of Service Quality

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Abstract

IEEE is preparing its new WLAN standard 802.11e in order to be able to cope with the emergent needs of real time traffic over wireless networks. Within this new standard there is an element called the QBSS (QoS enhanced) load element which should help in choosing the better access point among many. In this paper we show that this element cannot help making true decisions in many cases and address some of these cases. Additionally we suggest a small adjustment in the element which performs better than the current version.

1 Introduction

The tremendous success of the 802.11 technology is highly visible. The WLAN standard 802.11 has already proven to be one of the best marketing products for wireless services. Through Quality of Service (QoS) capabilities which are still in making, QoS demanding services such as Video on demand, Voice over IP (VoIP) and gaming can then be used in a wireless setting. A crucial feature which is required to enable flawless operation of the mentioned services is guaranteed traffic treatment, in the sense that the needed traffic characteristics are adhered by the wireless network infrastructure. The IEEE 802.11e task group envisages solving this problem in the near future with a new standard [1] [6].

For service providers hotspots are very attractive. Hotspots make it possible to have high connection rates on the move, while it should be noted that moving stations are not in the focus of the current WLAN standards [7, 8]. Hotspots are easily installed and very often several access points, sometimes belonging to different service providers, cover intersecting regions. A station has to choose from all reachable access points the one offering the best service quality.

The new standard IEEE 802.11e extends the existing 802.11 standard by adding QoS parameters. By this, 802.11e enables QoS enhanced access points

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[1] current draft version is 12.0

(QAP) to cope with real-time traffic that is delay-sensitive, jitter-sensitive, error-prone etc. such as voice and video streams (see [1] for a detailed overview). In consequence, the whole new 802.11 series is supposed to operate on access points and wireless stations with QoS enhancement (QAP and QSTAs) and without it (AP and STAs). The issue of QoS is addressed in the new standard IEEE 802.11e by introducing a new element called the QBSS (QoS enhanced basic service set) load element, which is part of the beacon frames generated by QoS enhanced access points (QAP) and contains information on the current traffic situation. It includes three parameters: station count, channel utilization and available admission capacity. The station count is the total number of stations currently associated with the access point. The channel utilization rate is the normalized value of the total channel utilization which gives the percentage of the time the channel is sensed to be busy using either the physical or virtual carrier sense mechanism of the access point. The available admission capacity gives the amount of time that can be used by explicit admission control. These three parameters can be used on one hand by a QoS enhanced access point to decide whether to accept an admission control request. On the other hand the QBSS load element parameters can also be used by a wireless station to decide which of the available access points to choose.

Research in the area of QoS in 802.11 networks concentrates mainly on the evaluation of the performance of the 802.11e drafts and related improvement proposals [3, 4, 5]. In this paper we assume that QoS handling is given and works as expected, the main question we strive to answer is: how should a QoS enhanced station (QSTA) decide which QoS enhanced access point to use, when multiple QAPs are present in its environment. Does the extension proposed in the standard 802.11e provide sufficient information to select the appropriate access point?

We evaluate the significance of the three parameters of the QBSS load element in a simulation study using the ns-2 network[2] simulator [2], where we determine the coefficient of correlation with some QoS metric. Different QoS metrics are used depending on the type of traffic (voice, video, etc) under consideration.

It turned out that none of the three QoS parameters of the QBSS load element shows a significant correlation with any of the QoS metrics for different types of traffic. We conclude that the parameters of the QBSS load element are neither sufficient nor suitable for describing the expected QoS. Instead we found the number of already present connections of the regarded type (if we look at video traffic that is the number of already connected video transmissions) correlates strongly with the respective QoS metric. Therefore we propose to enhance the QoS description of the QBSS load element by another field holding the number of existing connections.

The rest of the paper is structured as follows: After a summary of the current status of the 802.11e MAC protocol and its functioning in Section 2, we present different scenarios that were simulated with the ns-2 network simulator in Section 3. Section 4 discusses the simulation results in detail. Based on the gained results, we suggest an enhancement in the QBSS load element to achieve improvements in finding the best suited QAP depending on the required QoS in Section 5. Finally, Section 6 concludes this paper.

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[2]Several implementations of 802.11e mechanisms are already available

2 The Basics of the IEEE 802.11e Standard

There are two main functional blocks defined in 802.11e. These are the channel access functions and the traffic specification (TSPEC) management. We will in this section describe the channel access function which is a key part of the simulation study. The main idea behind the development of the IEEE 802.11e QoS facility is the lack of sufficient QoS management over WLAN. To solve this problem, the IEEE 802.11e task group introduced an obligatory function for the MAC layer called hybrid coordination function (HCF) composed of a combination of two sub functions, EDCA (enhanced distributed channel access) for prioritized channel access (similar to DiffServ) and HCCA (HCF controlled channel access) for parameterized channel access (similar to IntServ). The HCF splits the time frame into a contention and a contention-free period assigning it to EDCA or HCCA respectively. Different applications having different QoS requirements are differentiated and handled correspondingly using one or both of these functions.

In the draft, there exists a new central control mechanism of HCF which is called the hybrid coordinator (HC). The hybrid coordinator, which is collocated at the QoS enhanced access points, is responsible for the management of the use of EDCA and HCCA in a cooperative manner. Basically the hybrid coordinator makes the decision about when and how to use EDCA and HCCA, it assigns transmission opportunities (TXOP) to the stations defining the time interval in which they are allowed to send their MPDUs (MAC Protocol Data Unit). TXOPs can be given by using one of these two functions with respect to the needs of the stations. The HC can start a contention free period during the contention period by sending a *CFPoll (contention free poll)*. A possible combination of contention periods and contention free periods is illustrated within the standard draft as given in Figure 1 where a CAP is the controlled access phase of the hybrid coordinator. As can be observed from this figure, there is no observable regularity of the occurrences of controlled access phases. After sending a beacon period, hybrid coordinator starts contention free period. Following the end of the contention free period, contention period is started. In the second beacon period one can see that additional contention free period is started in between two contention periods for a short period of time. A summary of both functions/periods and how HCF uses them is given in the following two subsections.

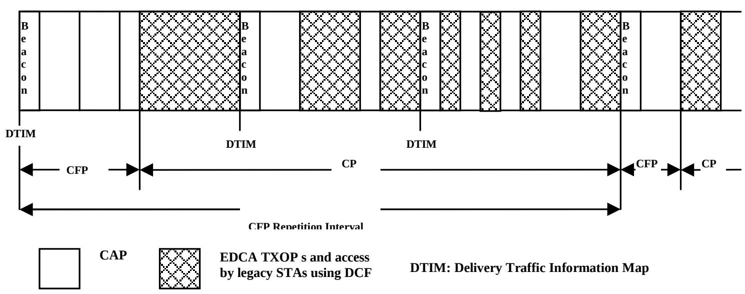


Figure 1: CAP/CFP/CP periods

In the following two subsections, we try to make it clear which functionalities of EDCA and HCCA affect their behavioural prediction. This will help understanding the correlation analysis of the third section.

2.1 Enhanced Distributed Channel Access (EDCA)

The enhanced distributed channel access function is defined to offer prioritized channel access. Traffic streams using this function are assigned user priorities at layers higher than the MAC layer. The assignment of user priorities is left to the service providers offering a high flexibility for network management. At the MAC layer, user priorities are grouped into 4 access categories. The access to the channel during the use of the EDCA function is also called a contention period because all access categories compete with each other to win the so called EDCA transmission opportunities. Stations receiving EDCA TXOPs are allowed to send their packets to the access point. Each access category has a backoff timer that is used for the contention process and is measured in *slotTimes*. There is a different maximum length of the transmission opportunity assigned to each access category. Different TXOPs makes sure that channel is not occupied with long frames of low priority packets. The maximum time length an access category can use for sending one frame is restricted with the TXOPs.

Consequently, there are four main parameters enabling the traffic differentiation by the use of EDCA. These are *CWmin[AC]* and *CWmax[AC] (minimum and maximum contention window lengths for each access category)*, *AIFS[AC] (arbitration inter frame space)* and *TXOPLimit[AC] (maximum duration an access category can use to send a frame)*. The values of these parameters are advertised at the beginning of each beacon period by the access point within the EDCA parameter set element. This element includes all EDCA related parameter values needed for the proper operation of the QoS facility during the contention period. Access points can tune the values of these parameters during run time with respect to channel load situation and networking policies. This point is open for further research and will be product specific on each access point.

The contention procedure is very well defined for EDCA, making simple reasoning possible such as if there is more traffic on the channel, there will be more collisions during contention. Additionally there will be more sources occupying the channel if there is more traffic. These two problems increase the loss and delay rates directly. Although some exceptions exist, which will be discussed in the third section, the loss, delay and jitter rates of traffic streams are mostly directly proportional to the load element parameters.

2.2 HCF Controlled Channel Access (HCCA)

In case a traffic stream has some constraints which cannot be dealt with the use of EDCA, the owner of this stream can tell the access point that this specific traffic stream needs to be polled in the schedule of HCCA. The hybrid coordination function uses HCCA in order to make sure that strict QoS requirements such as delay and loss rates of real time traffic streams are satisfied. During transmissions, the hybrid coordinator has a higher medium access priority compared to non access point stations by waiting only one *point coordination function inter frame space (PIFS)* period, which is smaller than *AIFS[AC]* (see above). Thus, the hybrid coordinator can send its own packets and assigns HCCA TXOPs to other stations before any station using EDCA can have access to the channel after the channel has been sensed to be idle. All stations are informed about the beginning and the end of the use of HCCA. This allows the hybrid coordinator to have control over transmissions.

Any station wanting to use the HCCA for transmission sends a management frame to the QAP, which includes the traffic specification (TSPEC) of the current stream, thus giving details about its requirements. Traffic specifications include all necessary information to describe a type of traffic like nominal MAC protocol data unit (MSDU) size, mean data rate, suspension interval, delay, surplus bandwidth allowance and maximum service interval where the service interval (SI) is the time between successive transmission opportunities assigned to a traffic stream. Using this information, the hybrid coordinator should decide whether or not to accept the incoming traffic stream and what kind of scheduling mechanism to use in case of acceptance. This decision algorithm is an open issue in the standard and is one of the most challenging tasks to be realized.

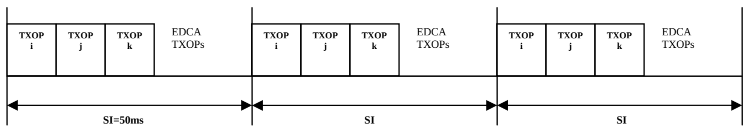


Figure 2: Schedule for three (i-k) QSTA streams

If the QSTAs send traffic specifications including their allowable maximum service intervals, then the draft recommends a scheduling method which has relatively a better organized structure, affecting the traffic treatment and the experienced QoS significantly Figure 2 shows the difference. Compared to Figure 1, where a regularity of the access phases does not exist, here on the contrary the transmission schedule shows an ordered behaviour. One can see that the distributed TXOPs are repeated at the beginning of each service interval so that stations have the chance to send their packets periodically. The recommended practice of the standard describes the choice of the service intervals as follows. First of all, the access point finds the smallest of the maximum service intervals. Afterwards, it selects a number which is smaller than the smallest maximum service interval and which is a sub multiple of the beacon interval. This means the service interval is determined by the incoming traffic and this information is only implicitly available to the stations. Additionally the amount of time reserved for contention free period, hence to the HCCA TXOPs, is left to the hybrid coordinator except that it must be smaller than the so called dot11CAPlimit (max percentage of time that can be reserved for controlled access phases). These two variables (service interval and the time reserved for contention free period) are the main factors determining the structure of the schedule. In the following section, we are going to concentrate on the effects of these two variables to the quality of information given by QBSS load elements and see that depending on these variables, the new protocol shows unpredictable behaviour which avoids that load element parameters give reliable information about the QoS one may expect from an access point.

3 Simulations

In order to show the information given by the QBSS load element, we run simulations with different traffic and parameter combinations. We concentrated on the effects of the percentage of time reserved for HCF controlled channel access and the service interval length chosen by the access point under mixed traffic load.

The aim of this paper is to find parameters that are indicative for QoS of each traffic type (like voice, or video traffic) in an environment exposed to mixed traffic as described below. For this purpose we measure the amount of useful information in the QBSS load element through its correlation with our QoS metric of interest. The considered QoS metric depends on which type of traffic from the traffic mixture is of interest. We expect that channel utilization and number of connected stations show positive correlation with all QoS metrics while the available admission capacity correlates negatively with all QoS metrics. Note that alternating sign of the correlation across the system parameters as well as a high variability indicates low reliable expressive power of the QBSS load element.

The results of the following subsections show that, the information captured by the QBSS load element is seemly inconsistent. Therefore we included an extra parameter in the correlation study that is the number of traffic streams of the different types of traffic. Traffic is divided up into different priority classes and some of the different types of traffic are associated with different priority classes, we therefore will discuss the priority classes rather than the traffic types. We show that this extra parameter is in many cases highly correlated with the QoS metric and therefore we propose to include the number of stations guaranteed the different priority levels as an additional parameter in the QBSS load element. Especially for voice and video traffic streams QoS evaluation can be substantially improved.

3.1 Simulation Environment

We consider as infrastructure a QoS enabled basic service set (QBSS) composed of a QoS enabled access point (QAP) and a number of stations (QSTAs) associated with the QAP. A slightly modified version of Qiang Ni's ns2 implementation of EDCF/HCF is used to perform simulation runs based on this infrastructure [9].

Although 802.11e defines many parameters, we focused on the service interval (SI) and the relative amount of time reserved for HCCA as system specific variables. Together with the considered traffic types, we input a total of three variables. We define 7 different traffic types similar to the work in [3, 5, 12] as follows.

1. Bidirectional constant bit rate (CBR) voice traffic using UDP with a packet size of 160 bytes and packet interval 20ms (8 Kbytes/s) corresponding to the VoIP codec G.711. (1st access category)
2. CBR video traffic using UDP with a packet size 1280 bytes and packet interval of 10ms (128 Kbytes/s). (2nd access category) (High quality Video)
3. 12 simulated VBR video traffic streams using UDP with minimum packet size of 28 and maximum packet size of 1024 bytes with an average packet interval

of 23ms corresponding to 30Kbytes/s. (2nd access category) (Average Quality Video)

4. Bidirectional interactive traffic using TCP with a packet size of 1100 bytes and exponentially distributed arrival rates having an average of 50ms on time, 30ms off time and sending rate of 60Kbits/s during on times corresponding to an average of 10Kbytes/s. This complies with the interactive traffic definition of 3GPP TS 22.105 and ITU G.1010. (3rd access category)
5. CBR Background traffic using UDP with a packet size of 1200 bytes and inter arrival time of 100ms corresponding to 12Kbytes/s. (4th access category)
6. VBR Background traffic using TCP with a packet size of 1200 bytes and exponentially distributed inter arrival times having an average of 1000ms off and 1000ms on times with a sending rate of 300Kbits/s corresponding to heavy load 160Kbytes/s traffic. (4th access category)
7. VBR Background traffic using TCP with a packet size of 1200 bytes and exponentially distributed inter arrival times having an average of 1000ms off and 200ms on times with a sending rate of 100Kbits/s corresponding to low load 11Kbytes/s traffic. (4th access category) (3GPP TS 22.105 Web Browsing-HTML definition.)

We investigate three different scenarios, where HCCA obtains 40%, 80% and 98% of the model time, respectively. We chose service intervals of length 4.5ms and 50ms as they were representative for the behaviour of most of the other combinations we tried. A simulation takes 30 seconds model time. Traffic streams enter to the simulation within the first 5 seconds with small intervals and the measurements of delay, jitter and loss rates are done over the last 10 seconds. The simulation results in general converge to steady state within the first 10 to 15 seconds. The traffic load in a simulation is composed of up to 7 bidirectional voice traffic streams (1st traffic type), 5 video traffic streams (2nd or/and 3rd traffic types), 10 bidirectional interactive traffic streams (4th traffic type) and 10 background traffic streams (5th and/or 6th and/or 7th traffic types).

4 Results

We ran simulations of an access point under the load as described in the previous section. The considered metrics are delay, jitter and loss rates of a certain traffic stream so that one can have an intuition about the possible QoS received by the users. For VoIP streams (1st traffic type), as opposed to the other traffic types, we evaluate the results on the basis of the mean opinion score (MOS) values defined in ITU-T Rec. G.107 which is the widely accepted metric of industrial organizations to measure the quality of VoIP applications [10, 11]. MOS rates calls on a scale of 1 to 5. The calculation of the MOS value is done firstly by calculating the so called rating factor R which is also defined in ITU-T Rec. G.107.

$$R = Ro - Is - Id - Ie - eff + A \tag{1}$$

$$MOS = 1 + 0.035R + R(R - 60)(100 - R)7 * 10^{-6} \tag{2}$$

where the factor Is represents impairments occuring simultaneously with the voice signal, Id represents delay impairments and Ie represents codec impairments. Additionally A is a compensation of impairments when there are some advantages existing on the user side. Ro, Is and Id are also other impairment factors decreasing the total MOS value. [10]. For calculating the MOS values we used a tool in which a number of default values are preset.

If from the mixed traffic on the access point one is interested in the voice traffic, the obtained MOS values must be studied, while for video traffic delay, loss rate and jitter are directly used as QoS metrics. The following two subsections are devoted to our results for voice and video traffic respectively. We skip here results for interactive and background traffic.

4.1 Voice Traffic Results

The common QoS metric for voice traffic is the MOS value. To find out what system parameters are indicative for the obtained MOS value we correlate the MOS value of the voice streams in our mixed traffic with the three QBSS load element parameters station count, channel utilisation and available admission capacity. Additionally we correlate the MOS value with a fourth system parameter, the number of existing voice traffic streams (labelled 1st priority #). We simulated different scenarios with two variables, the service interval length and the percentage of time reserved for HCCA. We distinguish two cases of service interval length, 4.5ms and 50ms and three different percentages of time reserved for HCCA, 40%, 80% and 98%, as shown in the total of six different configurations in Table 1. This table summarizes the correlation between MOS values and the QBSS Load elements and between MOS values and the number of voice traffic streams.

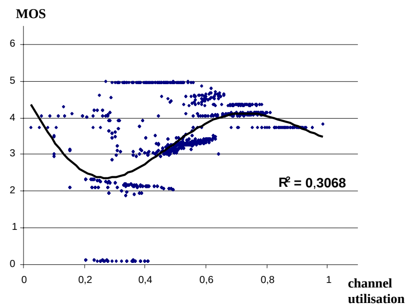
Table 1: Correlations of voice traffic; SI and HCCA percentage versus QBSS load elements and voice traffic number

	40%HCCA		80%HCCA		98%HCCA	
Service Interval	4.5ms	50ms	4.5ms	50ms	4.5ms	50ms
Station Count	-0.11	-0.29	-0.27	-0.25	0	-0.19
Channel Util.	0.55	0.01	0.20	-0.01	0.28	0.05
Avail. Adm.C.	0.06	0.26	0.14	0.59	0.11	0.08
1st priority #	-0.86	-0.69	-0.90	-0.70	-0.79	-0.73

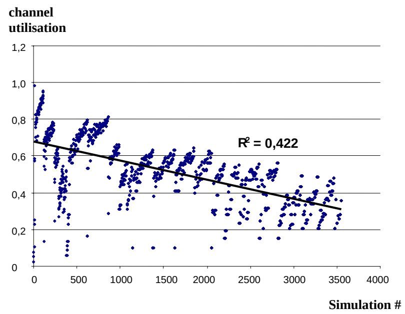
We observe that the number of stations indeed correlates negatively with the QoS metric, but correlation is for none of the system configurations more than roughly 30% which we consider low correlation. There is an intuitive explanation for this result. Some stations, like the ones producing small background traffic, put very little load on the system and hence have very little effect on QoS. Therefore one cannot estimate QoS based on the number of stations. It should be noted, however, that for the larger service interval the MOS value and the station count correlate slightly more since the hybrid controller can reserve transmission opportunities for each demanding stream and the remaining time used for EDCA determines the quality of the packets sent later on which is directly correlated with the number of stations.

For the short service interval, the number of connected stations correlates less with the MOS value and if 98% of the time is reserved for HCCA, lower priority streams only obtain TXOPs if there is no first priority stream requiring admission. Similar to the above argument then the number of stations does not correlate with the MOS value of the first priority stream.

For the correlation between channel utilisation and MOS value we observe the reverse. For the long service intervals correlation is negligible. This is because voice traffic has the highest priority and does in many cases not get disturbed by lower priority traffic. When using the short service intervals, however, voice traffic competes with many background traffic streams and surprisingly correlation between channel utilisation and MOS value gets rather high (See Fig. 3(a)). This result is mainly due to the increasing number of internal collisions over the access point. As the number of stations increases, the number of internal collisions increases and channel utilization becomes less (See Fig. 3(b)). Therefore we get lower channel utilization rates for high loads where the MOS values are very low. For lower loads we get channel utilization up to a hundred percent where the MOS values are very high. As a result, there is high positive correlation with the channel utilization rate.



(a) MOS versus channel utilization (Note that most of the points are between 0.2 and 0.9 causing a positive correlation of 0.55)



(b) channel utilization in the course of simulation runs (Note that the numbers of active streams of different types increase with the simulation number)

Figure 3: The relationship between Channel Utilization and MOS values during small service intervals

In case of longer service intervals, more available admission capacity means better MOS values for voice traffic. On the other hand if the service interval drops to 4.5ms, than there is no observable relationship between the available admission capacity and the MOS values. It is reasonable to have some positive correlation if the service interval is high. In such a case, if also the percentage of HCCA is enough, available admission capacity means that TXOPs could have been assigned for all the traffic on the access point, which indicates a positive correlation with MOS values. On the other hand, such a relationship does not exist if there is a small service interval. Available admission capacity reaches to minimum values just after one video and one voice traffic. At this point, depending on the percentage of HCCA being used, the results are mainly affected by the length of EDCA and not HCCA.

As illustrated in the last row in Table 1, we find that the number of connected 1st priority streams correlates much more (and negatively) with the MOS value than any of the QBSS load element parameters and hence seems to be a good indication for the expected QoS of voice streams.

4.2 Video Traffic

Because we do not have a metric like MOS defined for video traffic streams, we are going to give the correlations of the information elements with delay, jitter and loss rates of the video traffic streams. In fact, as given in Table 2, the results are very unstable for video traffic. If the traffic combination changes the results change also. Nevertheless the sign of the correlation is constant. The delay and the number of stations correlate positively, as expected.

Since voice traffic has higher priority than video traffic, the number of voice traffic streams increases the delay of video traffic directly. Additionally, video traffic streams affect each other more than all the other traffic streams, because video packets come more often and are larger. This causes a positive correlation between station count and delay. If the number of traffic streams associated with the access point increases, the schedule of the HC becomes more stable and therefore the jitter values decrease, which results in negative correlation. The correlation with the loss rate is more stable compared to others, which can be explained in a straightforward manner. On the other hand, channel utilization and available admission capacity shows nearly no correlation with delay, jitter or loss rates.

Table 2: Correlations of video traffic; SI and HCCA percentage versus QBSS load elements and video traffic number

	4.5 ms SI			50ms SI		
	Delay	Jitter	Loss	Delay	Jitter	Loss
	40% HCCA					
Station Count	-0.11	0.08	0.22	0.23	-0.23	0.22
Channel Util.	-0.21	0.05	-0.40	-0.05	-0.14	-0.06
Avail. Adm.C.	-0.23	0.59	0.68	-0.02	0.07	-0.02
2st priority #	0.69	-0.37	0.11	0.90	-0.71	0.89
	80% HCCA					
Station Count	-0.11	0.08	0.22	0.23	-0.23	0.22
Channel Util.	-0.21	0.05	-0.40	-0.05	-0.14	-0.06
Avail. Adm.C.	-0.23	0.59	0.68	-0.02	0.07	-0.02
2st priority #	0.69	-0.37	0.11	0.90	-0.71	0.89
	98% HCCA					
Station Count	0.12	0.01	0.15	0.26	-0.15	0.29
Channel Util.	-0.18	0.10	-0.18	-0.09	-0.07	0.23
Avail. Adm.C.	0	-0.02	0	0.13	0.04	-0.19
2st priority #	0.57	0.07	0.51	0.72	-0.81	0.83

The effect of the number of video traffic streams has mostly a high correlation with delay, jitter and loss rates of the video traffic. This is due to the fact that video traffic streams are relatively heavy loaded and constitute the main channel utilization. If the service interval is small, at most one video traffic can receive TXOP and the remaining use the contention period. Because the contention period is short and video packets come very often, the bandwidth reserved to the video traffic is not enough and the loss rate increases suddenly. The jitter rate drops because the video packets coming very often allow a self repeating schedule keeping delays nearly constant. But this does not have any importance if the service interval is low, because the loss rate increases very fast making it impossible to have more than two video traffic streams with an acceptable level of QoS.

If the service interval is large and the time reserved for contention free period is long, TXOPs given at the beginning of the service interval do not fully utilise the amount of time reserved for scheduling which results the start of contention period. Within the contention period, as the number of voice streams increases, the loss rate increases due to collisions and delay increases as well. On the other hand longer delays achieve saturation, decreasing the variation in delay.

5 Evaluation of Results and Enhancement Recommendation

The results of the Sections 4.1 and 4.2 show that the load element parameters channel utilization and available admission capacity are capable of giving meaningful information in some of the parameter combinations because they are moderately correlated with the metric of interest (MOS or delay, jitter and loss rates) in these cases. However this information is not reliable because it depends on many other variables and is not stable. The station count is in none of the cases a reliable source of information to estimate the expected QoS over an access point as there is no observed correlation bigger than -0.30. Such a low correlation cannot be regarded as a source of information in decision making. Even more so since there is another parameter, the number of streams belonging to the respective priority class, that correlates much stronger.

In fact the number of traffic streams in each priority should definitely give an idea about the expected QoS, because in most cases, the number of any kind of traffic that can be transmitted over an access point has a maximum value and this depends on the standard being used. For 802.11b the maximum number of voice calls using G.711 codec is about 5 which can further be optimized to 7 with more efficient algorithms [13]. For this reason we also compared the correlation between the number of traffic streams in each priority class and the QoS indicator values (MOS, delay, jitter and loss rates). The correlations between the number of traffic streams using the first priority and the QoS indicators can be found in Table 1 and the second priority can be found in Table 2. As it can be observed, the correlations reach up to -0.9 for some of the cases. Except for the correlation between jitter and the number of second priority traffic, the magnitude of the correlations is significantly higher than what we had for the load element parameters. Hence, it is worth having this additional information in the QBSS load element which does not bring a considerably extra load to the beacon frame. An extension of the current draft with the number of traffic using different priority levels can ease the choice procedure substantially.

6 Conclusion

In this paper, we presented the QBSS load element and its use in the context of 802.11e. Our simulation results showed that choosing a QAP based upon the fields of the received QBSS load element fields, does not always lead to an association with the best available access point.

In order to delineate the poorness of the QBSS load element information, we listed the results of the correlation between the QBSS load element parameters and QoS factors like delay, jitter and loss rate. We showed that, in most of the cases the correlation is very low and unfortunately even the sign of the correlation can change if one uses a different set of parameters.

We observed that in all cases with decreasing HCCA percentage, the decision accuracy improved significantly supporting our claim that the HCCA brings extra irregularity and complexity to the new standard. We conclude that, depending on the internal configuration of the QAP, meaning the settings of the 802.11e relevant parameters, the provided network service cannot be bound barely on the load information.

Although we presented two of the most important parameters affecting the performance of 802.11e, incorporating more parameters into the decision process, for instance considering the number of traffic streams in different priorities, can improve the accuracy of the decision. We are going to analyse other parameters of the TSPEC like surplus bandwidth allowance and delay bound, which will be included in our next study.

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